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FROM: PROI (STINFO) 11 Oct 2001

SUBJECT: Authorization for Release of Technical Information, Control Number: **AFRL-PR-ED-VG-2001-200**
C.T. Liu, "Estimating the Initial Crack Size in a Particulate Composite Material: An Analytical and Experimental Approach" (VIEWGRAPHS)

**ASME Winter Meeting** **(Statement A)**
**(New York, NY, 11-16 Nov 2001) (Deadline: 02 Nov 2001)**

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PHILIP A. KESSEL Date
Technical Advisor
Space and Missile Propulsion Division

Title: Estimating the Initial Crack Size in a Particulate Composite Material: An Analytical and Experimental Approach

Slides 1-3: Self Explanatory

Slide 4: $K_{th}$ is the threshold value of the stress intensity factor below which the crack will not grow. From Fig (a) and for a given $K_{th}$ , we can determine t*, which is the time corresponding to $K_{th}$. From Fig. (b), for a given t* we can determine a*, which is the threshold crack length

Slide 5-8 are plots of statistical distribution functions based on test data.

Slide 9 shows the values of the distribution parameters for four different statistical functions.

Slide 10 shows the values of the predicted inherent initial critical crack length, $a_o$, for the onset of crack growth, a* and t*, defined in slide 4, and the measured finial critical crack length, $a_c$, for the unstable crack growth.

Slide 11 shows a plot of the maximum stress versus the corresponding time for different crack lengths. By shifting the un-precracked specimen data vertically downward until they superpose upon those of the pre-cracked specimen, we can obtain an estimate for the inherent initial critical crack length in the un-precracked specimen. The dash line in the figure represent the vertically shifted curves. According to the figure, the inherent initial critical length is approximately equal to 0.1 in., which compares well with the predicted value of 0.12 in.

Slide 12 shows the x-ray images at different stretches. It shows the inhomogeneity of the macrostructure as a function of the applied stretch.

Slide 13 shows the specimens with different crack sizes at different times. The two large black dots are pen markers, and they are not cracks.

Slide 14 is self explanatory.

# Estimating the Initial Crack Size in a Particulate Composite Material: An Analytical and Experimental Approach


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PRSM

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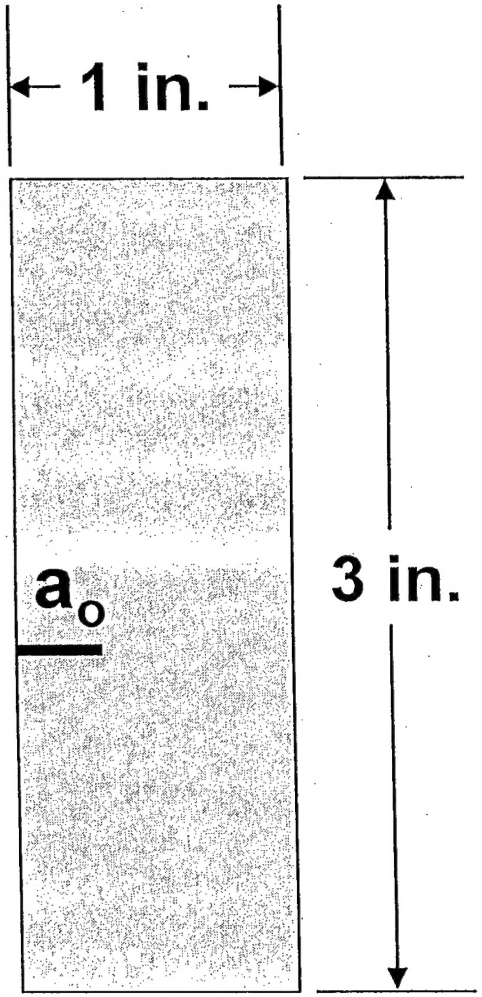
# Objectives

- Determine the Inherent Critical Initial Crack Size in a Particulate Composite Material.
- Determine the Statistical Distribution Function of the Inherent Critical Crack Size.
- Normal Distribution
- Two Parameter Lognormal Distribution
- Two Parameter Weibull Distribution
- Second Asymptotic Distribution of Maximum Value

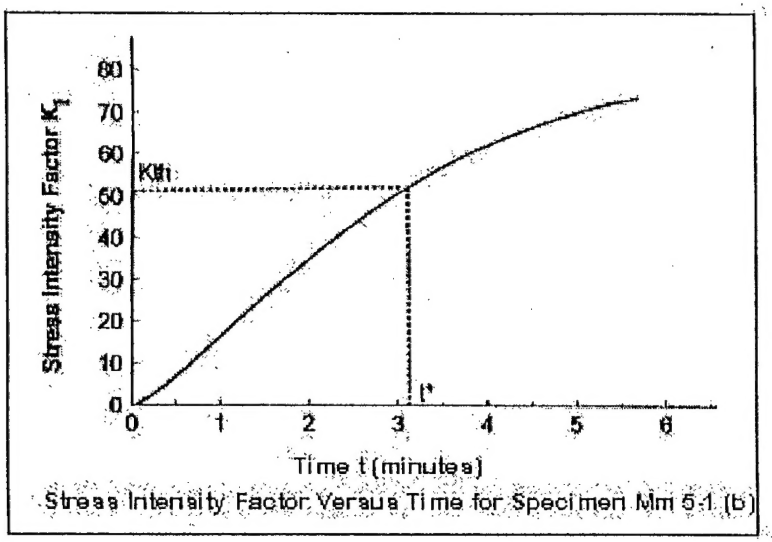
# Specimen Geometry




$a_o$ = 0.0 in.
= 0.1 in.
= 0.2 in.
= 0.3 in.

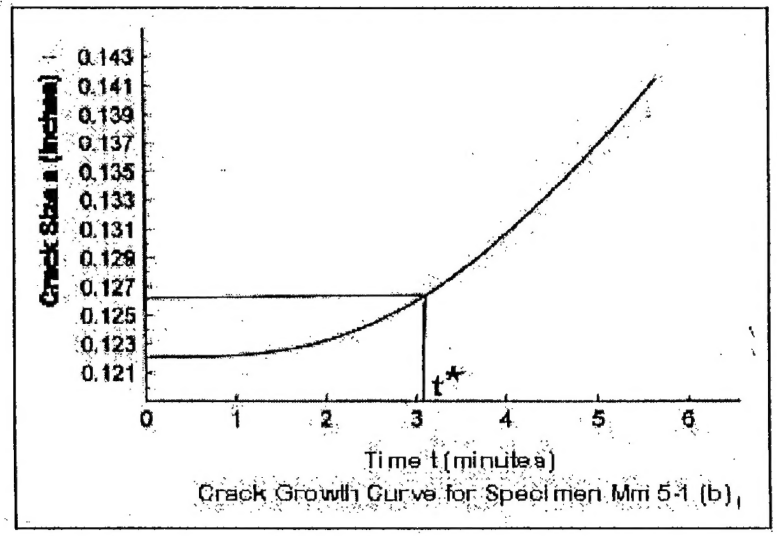
A2761.ppt

# Stress Intensity Factor Versus Time for Specimen Mm 5-1 (b)



Stress Intensity Factor Versus Time for Specimen Mm 5-1 (b)

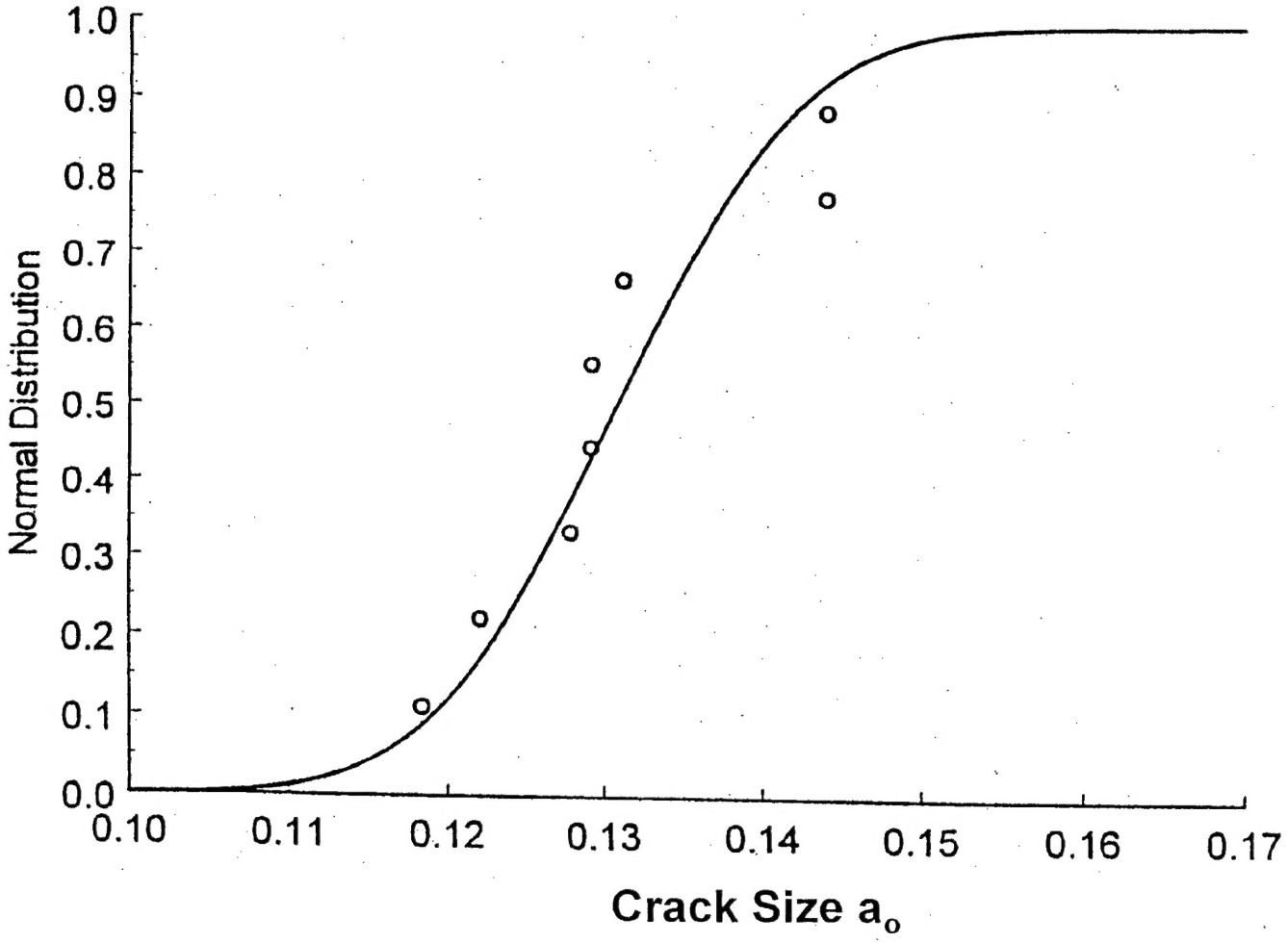
a



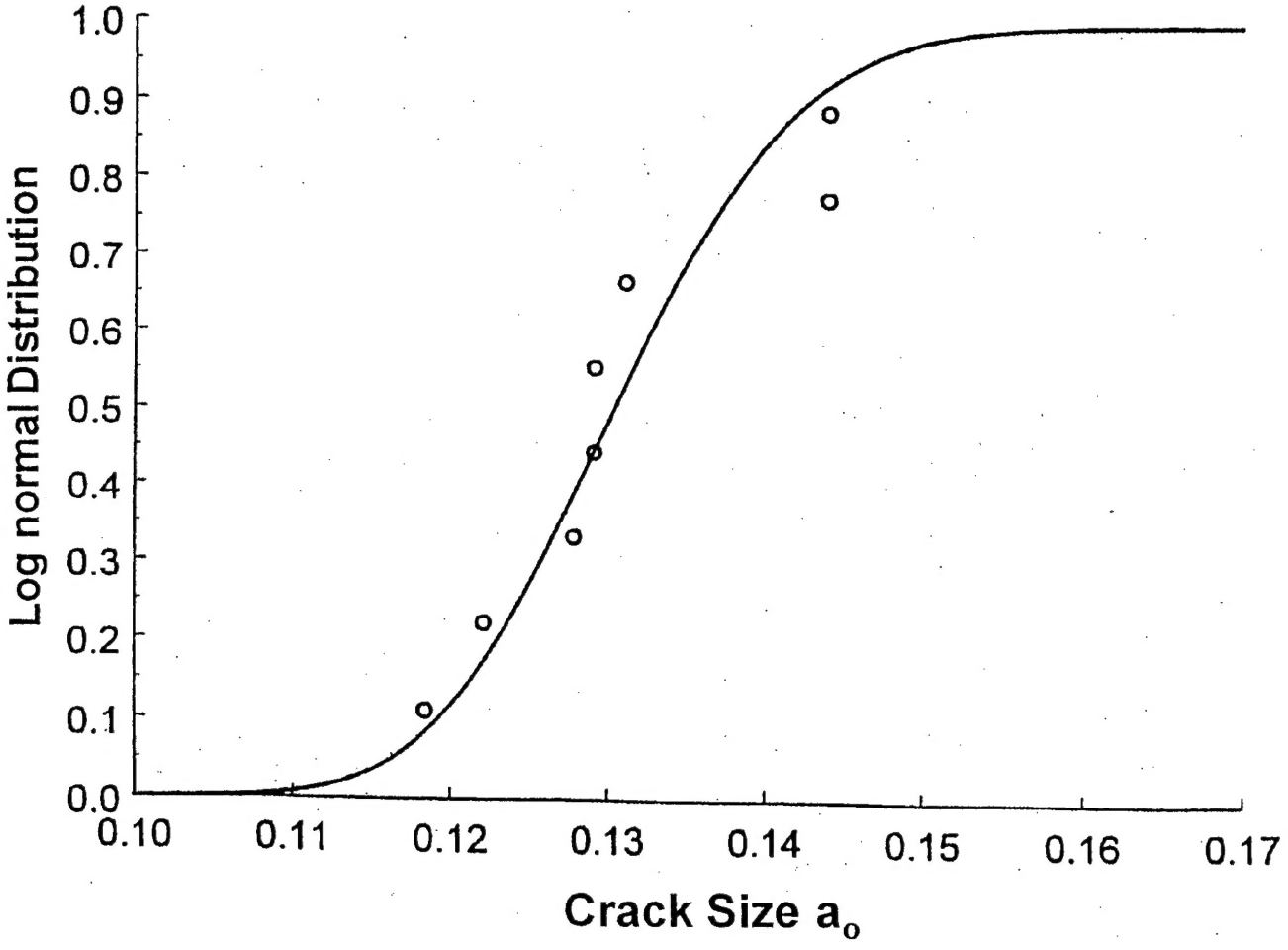
Crack Growth Curve for Specimen Mm 5-1 (b)

b

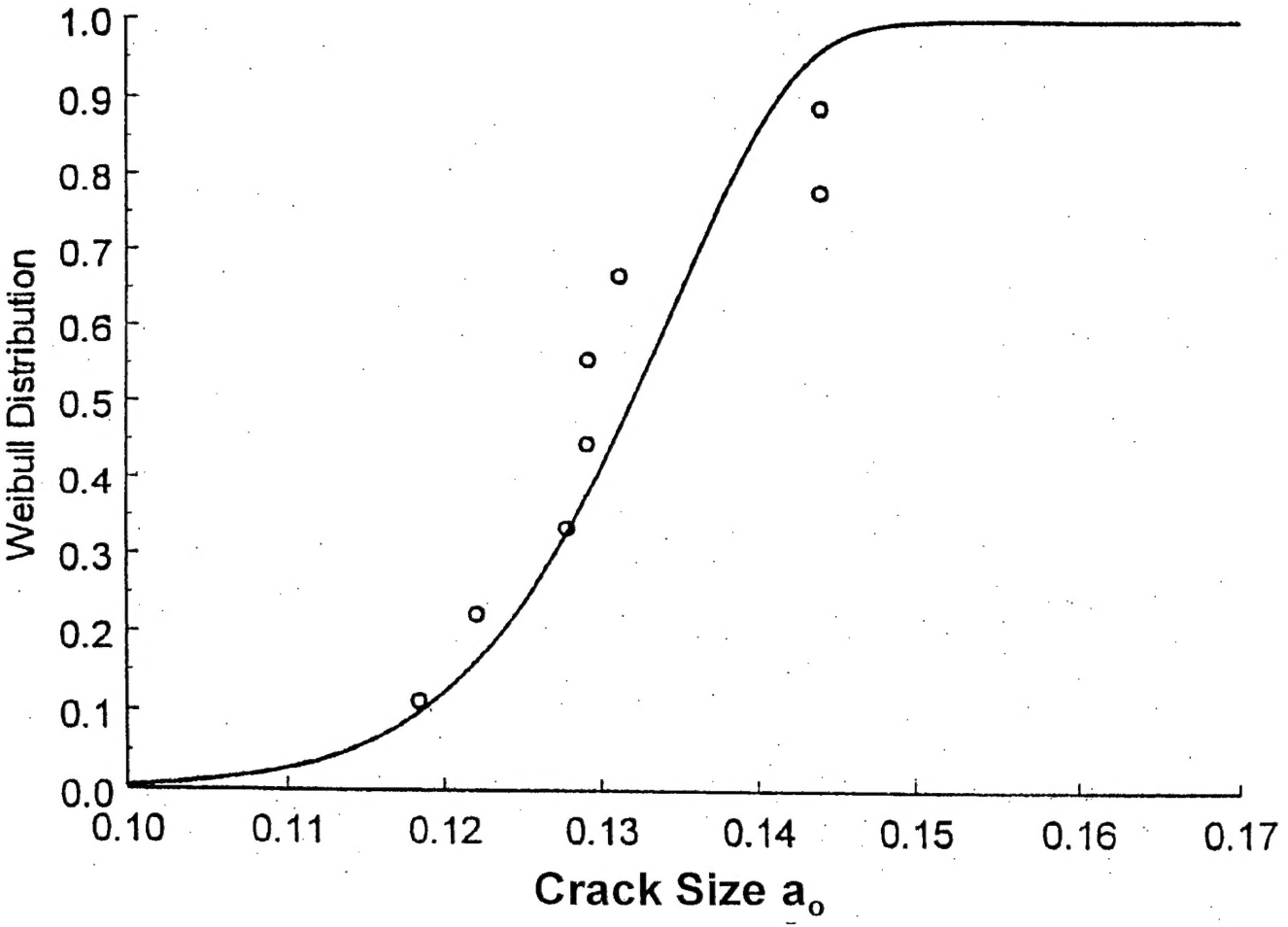
# Normal Distribution Plot for $a_o$



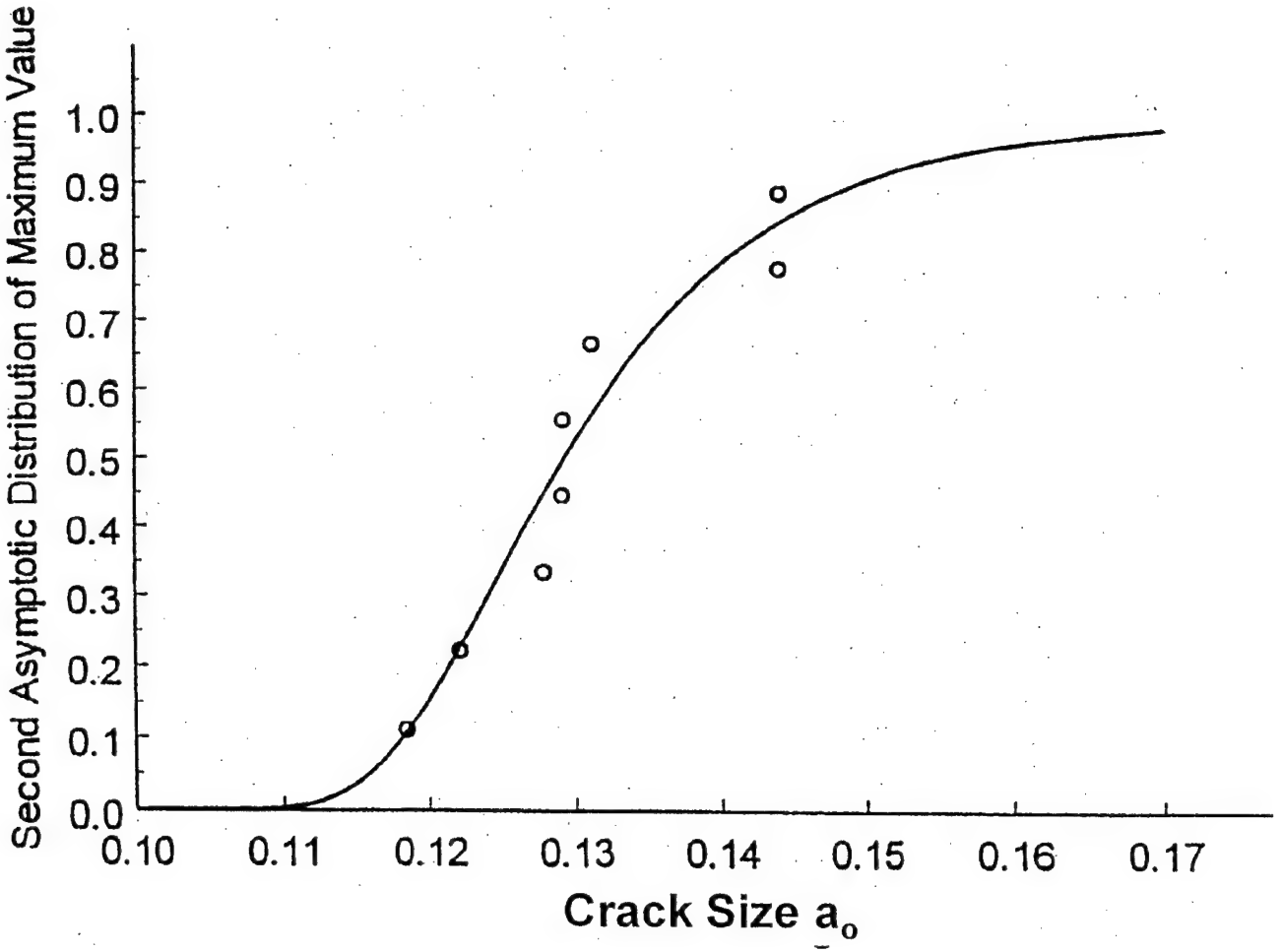
# Log normal Distribution Plot for $a_o$



# Weibull Distribution Plot for $a_o$



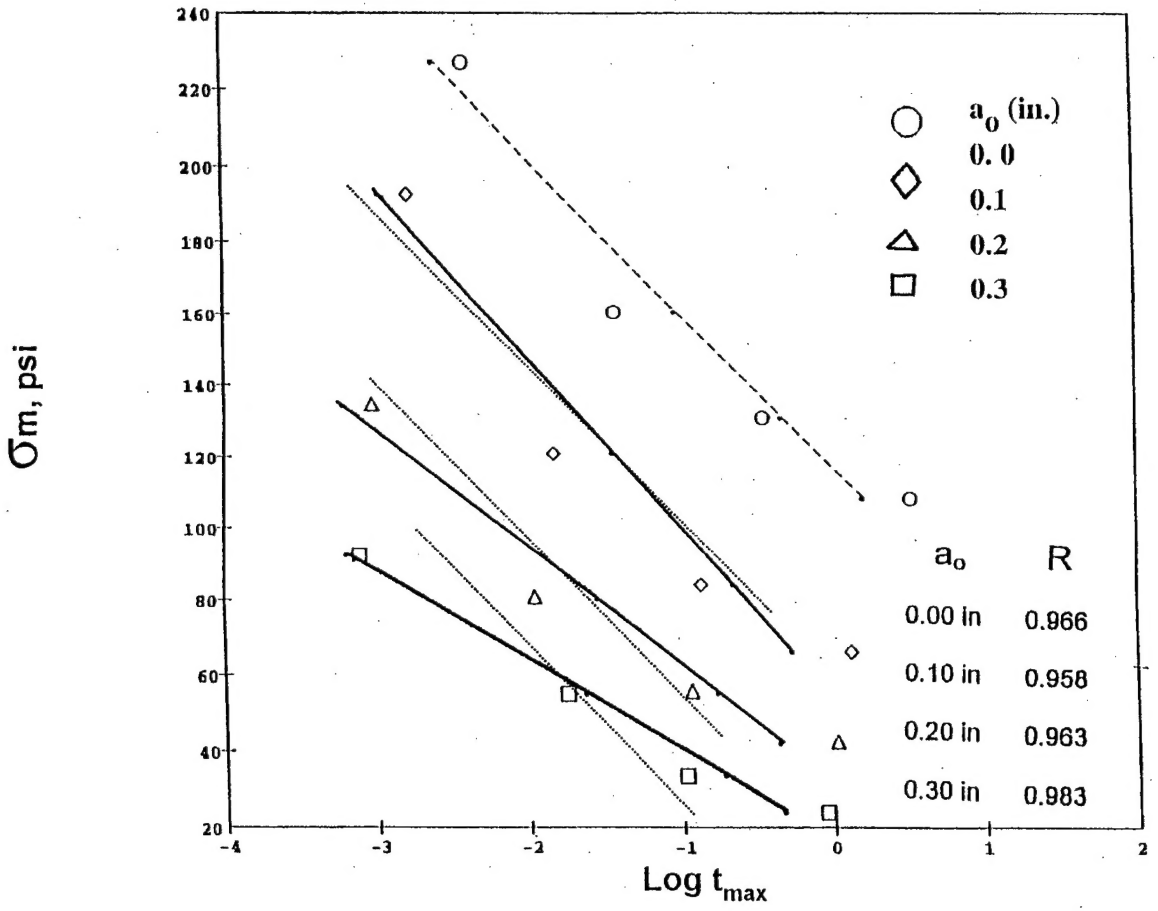
# Second Asymptotic Distribution Plot for $a_o$



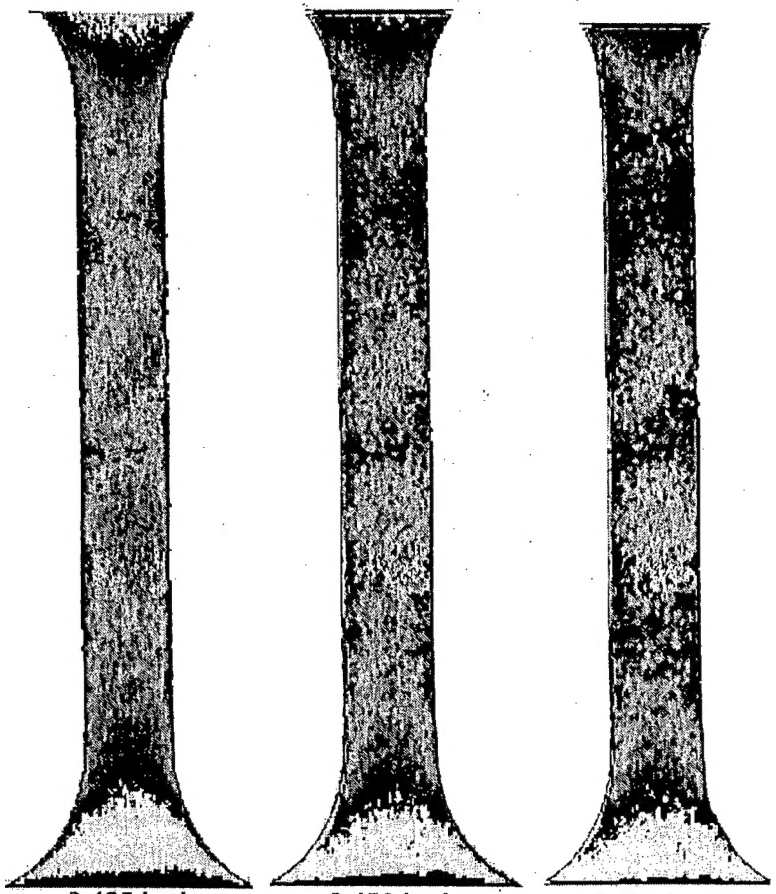

# Distribution Parameters for Normal, Lognormal, Weibull and Asymptotic Distributions

| | $a_0$ | $a^*$ | $a_c$ |
|---|---|---|---|
| $\mu$ | 0.1308 | 0.1344 | 0.1462 |
| **s** | 0.0092 | 0.0090 | 0.0079 |
| $\mu^*$ | -2.037 | -2.0092 | -1.9242 |
| $\sigma^*$ | 0.07021 | 0.06692 | 0.053961 |
| $\alpha$ | 17.5546 | 18.4513 | 23.0450 |
| $\beta$ | 0.1348 | 0.1383 | 0.1497 |
| **k** | 13.2524 | 13.80.81 | 17.1205 |
| $\upsilon$ | 0.1258 | 0.2195 | 0.1419 |

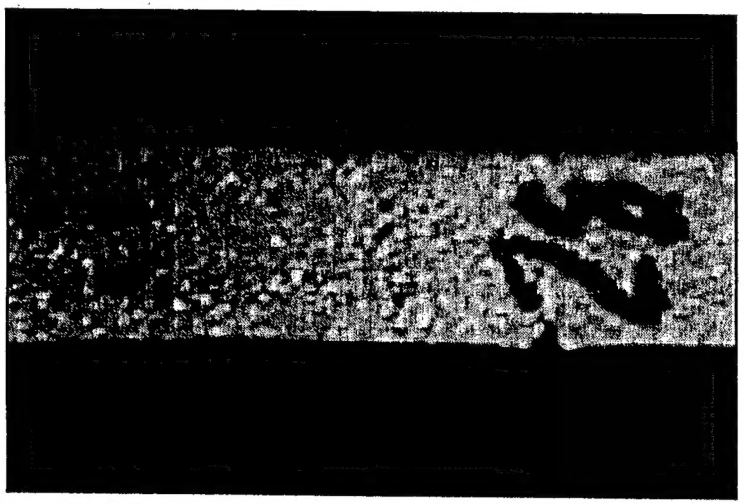
| $a_o$ (in.) | $a^*$ (in.) | $t^*$ (min.) | $a_c$ (in.) |
|---|---|---|---|
| 0.1221 | 0.1263 | 3.0755 | 0.1415 |

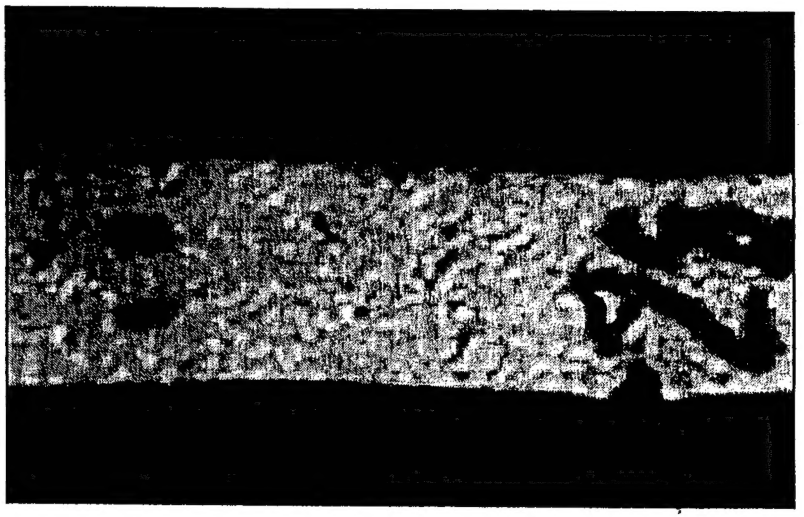



## Maximum Stress Vs Maximum Time




## X-Ray Images





# Crack Specimen

# Conclusions

- For the material studied, The estimated inherent critical crack size is 0.12 in., which compares well with experimental value.
- The inherent critical crack size follows the second asymptotic distribution of the maximum value.